

SITE: FL Phosphate Initiative
BREAK: 17-8
OTHER: v. 63

Journal of Exposure Analysis and Environmental Epidemiology, Vol. 8, No. 2, 1998 207

ENVIRONMENTAL RADIATION LEVELS IN CENTRAL FLORIDA'S PHOSPHATE MINING DISTRICT

KENNETH G. ORLOFF* AND WESLEY NALL†

*Agency for Toxic Substances and Disease Registry
Public Health Service
U.S. Department of Health and Human Services
Atlanta, Georgia

†Polk County Public Health Unit
Radiological Health Section
Polk County, Florida

Environmental levels of radionuclides and gamma radiation were measured in two communities located near active phosphate mining areas in Florida. Activated carbon canisters and alpha track detectors were used to measure indoor air levels of radon in approximately 100 private homes. Elevated levels of radon (> 4 picocuries per liter [pCi/L]) were detected in 8 of 27 homes in a community built on reclaimed land that had been previously mined. In a nearby community built on unmined land, elevated levels of radon were detected in 1 of 69 homes. All of the homes with elevated levels of radon were built on concrete slabs. Outdoor gamma radiation levels were significantly greater in the reclaimed area than in the unmined area. Air particulates collected from outdoor ambient air at three locations did not contain elevated levels of radionuclides.

INTRODUCTION

Large quantities of phosphate deposits are located in the "land-pebble district" of central Florida. Surface mining of these deposits produces 75% of the nation's phosphate production (USNWR, 1995). In many areas, previously mined land has been reclaimed for recreational, residential, and other uses.

Naturally occurring uranium and its decay products are associated with these phosphate deposits. One of the decay products of the uranium-238 decay series is the radioactive gas, radon. Radon can diffuse upwards through the soil and enter homes and other structures built over the deposits. When radon decays it forms daughter products that readily attach to air-borne particulates. These particulates can then be inhaled and deposited in the lungs. When the radon daughters decay, they emit alpha particles that irradiate lung tissue. Thus, long-term exposure to elevated levels of radon can increase a person's risk of lung cancer (Pershagen et al., 1994).

1. Address all correspondence to: Kenneth G. Orloff, Ph.D., Agency for Toxic Substances and Disease Registry, 1600 Clifton Road, Mailstop E 32, Atlanta, GA 30333. Tel.: (404) 639-0616. Fax: (404) 639-0655. E-mail: KEO1.ATSDH@1.em.cdc.gov.

2. Abbreviations: ATSDR, Agency for Toxic Substances and Disease Registry; fCi/m³, femtocuries per cubic meter; pCi/L, picocuries per liter; PCPHU, Polk County Public Health Unit; μ R/hr, microRoentgens/hour; USEPA, U.S. Environmental Protection Agency.

3. Key words: Florida, phosphate mining, radon.



208 *Orloff and Nash*

Phosphate mining practices, particularly those used in the past, could have left significant quantities of uranium- and radium-containing materials at the surface (Roessler et al., 1983). Houses built on such material could be at increased risk for elevated levels of indoor air radon because of the reduction in protective soil overburden. In 1983, researchers from the University of Florida concluded that, "... about 75% of the land produced by present-day mining and reclamation practices would be satisfactory for unrestricted construction use, while about 25% would require restrictions on type of construction or would require special construction methods (Roessler et al., 1983)."

Community members have expressed concerns about the public health impact of human exposure to hazardous substances in the environment in phosphate mining areas in Polk County, Florida. Because of these health concerns, the Agency for Toxic Substances and Disease Registry (ATSDR) and the Polk County Public Health Unit - Radiological Health Section (PCPHU) investigated environmental levels of radionuclides and gamma radiation in two communities located near active phosphate mining areas.

METHODS

Investigation Area

The town of Bradley (also known as Bradley Junction) and the nearby community of Rolling Hills are in an area where there has been extensive phosphate mining. The houses in Rolling Hills are built on reclaimed land that was mined before 1971; in Bradley, the houses are built on land that has never been mined (Report No., 1978). Large tracts of previously mined or reclaimed land surround both communities, and phosphate mining continues in the area.

Staff from ATSDR and the PCPHU went door-to-door to homes in Bradley and Rolling Hills offering residents free indoor air radon testing. Each participant signed a consent form before testing was conducted.

Testing

Indoor Air. In March 1996, charcoal canisters were placed inside 109 houses in accordance with U.S. Environmental Protection Agency (USEPA)-recommended protocols. The canisters had a diffusion barrier to minimize moisture uptake by the charcoal. To the extent possible, the canisters were placed in open living areas away from walls, windows, heat sources, and drafts. At the end of a 7-day exposure period, the canisters were collected and sent by overnight mail to an USEPA-listed laboratory (Alpha Energy Labs, Carrollton, Texas) for analysis.

Alpha-track detectors were also placed in houses to measure long-term indoor air radon levels. The alpha-track detectors were placed in the same houses, at the same time, and in the same general area as the charcoal canisters. After 6 months of exposure, the alpha-track detectors were collected and sent by overnight mail to an USEPA-listed laboratory for analysis (Alpha Energy Labs, Carrollton, Texas).

Journal of Exposure Analysis and Environmental Epidemiology, Vol. 8, No. 2, 1998 209

Outdoor Ambient Air. Ambient air samples were collected from three residential lots located near previously mined or reclaimed areas. In Bradley, two air samples were collected from residential yards that were adjacent to railroad tracks and across from previously mined areas. In Rolling Hills, one air sample was collected from a residential yard that was adjacent to an area where land was being graded as part of a reclamation effort. A control (non-mining area) ambient air sample was collected at the PCPHU office in Winter Haven, Florida.

At each location, a high-volume, 24-hour ambient air sample was collected through a glass fiber filter, and the particulate matter trapped on the filter was analyzed for gross alpha, gross beta, and selected gamma-emitting radionuclides. An activated carbon trap in the air train was tested for ambient air radon levels.

Gamma Radiation. Ambient levels of indoor and outdoor gamma radiation were measured at a random selection of houses where radon tests were conducted. Gamma radiation was measured using a Ludlum Model 12S Survey Meter (Ludlum Measurements, Inc., Sweetwater, Texas) calibrated for radium against a pressurized ionization chamber. Indoor and outdoor levels of gamma radiation were measured at a height of 3 feet at 4 locations and averaged. In Rolling Hills, 16 houses were surveyed; in Bradley, 12 houses were surveyed.

RESULTS

Indoor Air

Activated carbon canisters were recovered from 106 of the 109 (97%) homes that were tested. Indoor air levels of radon ranged from 0.0 to 12.2 picocuries per liter (pCi/L). The average indoor air radon level in Rolling Hills was 3.02 ± 3.52 pCi/L (30 houses), and the average in Bradley was 0.63 ± 0.76 pCi/L (76 houses). The median indoor air level in Rolling Hills was 1.5 pCi/L, and the median indoor air level in Bradley was 0.5 pCi/L.

Alpha track detectors were recovered from 96 of the 109 (88%) homes that were tested. Indoor air levels of radon ranged from 0.2 to 13.6 pCi/L. The average indoor air radon level in Rolling Hills was 3.56 ± 3.39 pCi/L (27 houses), and the average in Bradley was 0.73 ± 0.75 pCi/L (69 houses). The median indoor air level in Rolling Hills was 1.8 pCi/L, and the median indoor air level in Bradley was 0.5 pCi/L.

Outdoor Ambient Air

Table 1 contains the levels of radionuclides detected in air particulates and the radon levels in outdoor ambient air.

Gamma Radiation

In Rolling Hills, the mean indoor and outdoor gamma radiation levels were 10 microRoentgens/hour (μ R/hr) and 13 μ R/hr, respectively; in Bradley, the mean indoor and outdoor levels were 7 μ R/hr and 8 μ R/hr, respectively. The highest indoor level of gamma radiation detected in this survey was 19 μ R/hr, which was detected in one house in Rolling Hills.

210 *Orlogj and Null*TABLE 1. Radionuclide Concentrations (fCi/m³) in Outdoor Ambient Air

Location	gross alpha	gross beta	Be-7	Cs-137	Rn-220	Rn-222
(1)	3 ± 1	20 ± 2	150 ± 60	< 2	< 200	25 ± 24
(2)	3 ± 1	18 ± 2	120 ± 60	< 2	< 110	65 ± 40
(3)	2 ± 1	13 ± 1	60 ± 40	< 2	< 40	110 ± 45
(4)	3 ± 1	14 ± 2	60 ± 30	< 2	< 20	38 ± 22

(fCi/m³) = femtocuries per cubic meter

(1) private residence, Bradley

(2) private residence, Rolling Hills

(3) private residence, Bradley

(4) control area, Winter Haven

DISCUSSION

Indoor Air

Indoor air levels of radon were measured using both activated carbon canisters and alpha-track detectors. A long-term test is a more accurate indicator of indoor air radon levels than a short-term test is, because it averages out short-term fluctuations that can occur as a result of climatic changes and seasonal variations in ventilation in the house. Therefore, the following discussion is based on results of the long-term, alpha-track tests.

The average indoor air level of radon detected in homes in Rolling Hills was 3.55 pCi/L; in Bradley, the average level was 0.73 pCi/L. Using Wilcoxon's Sum of Ranks Test, the difference between the two communities was statistically significant ($p < 0.002$).

The USEPA and the U.S. Department of Health and Human Services recommend that actions be taken to lower radon levels in homes to below 4 pCi/L (USEPA, 1992). In Rolling Hills, 8 of 27 houses tested (30%) had indoor air radon levels greater than 4 pCi/L. In Bradley, only 1 of 69 houses tested (1.5%) had an indoor air radon level that exceeded 4 pCi/L.

The reason for the difference between the two communities is not known, but it may be related to the fact that houses in Rolling Hills are built on reclaimed land; whereas in Bradley, the land has never been mined. The type of mining waste left on the surface after reclamation can significantly affect radon levels in homes built on the land (Roessler et al., 1983). No information is available on the type or depth of mining wastes that remain at Rolling Hills.

Only one house in Bradley had an elevated radon level. The owner of this house reported that fill material had been brought in to fill low, marshy areas on the lot before the house was built. It is possible that the fill material was mining wastes that contained radionuclides that are contributing to the elevated radon levels in this house.

Journal of Exposure Analysis and Environmental Epidemiology, Vol. 8, No. 2, 1998 211

The type of house construction also influenced indoor air radon levels. All of the houses with radon levels above 4 pCi/L were built with slab-on-grade construction. In Rolling Hills, the average radon concentration in a house with slab construction was 6.3 pCi/L (12 houses), compared with 0.9 pCi/L (15 houses) in "uncoupled" houses (structures with crawl spaces or mobile homes). The lower radon levels in uncoupled houses likely occur because the air space between the ground and floor allows for dilution and ventilation of radon as it escapes from the ground.

Outdoor Ambient Air

Table 1 contains the levels of radionuclides detected in air particulates and the radon levels in outdoor ambient air. The levels of radionuclides detected in air samples from the three residential yards and the control area (Winter Haven) were similar and within normal background levels. These levels do not pose a public health hazard.

Gamma Radiation

Indoor gamma radiation levels were less than or comparable to outdoor levels at all houses. These results suggest that there was no significant gamma radiation from materials used in the construction of the houses. Outdoors, isolated "hot spots" with gamma radiation levels of up to 25 μ R/hr were detected in some driveways. It is likely that the elevated gamma levels over the driveway were derived from radionuclides that were present in mine wastes used in constructing the driveway. These hot spots in the driveways were not used in calculating the average outdoor levels.

In Rolling Hills, the mean indoor and outdoor levels were 10 μ R/hr and 13 μ R/hr, respectively; in Bradley, the mean indoor and outdoor levels were 7 μ R/hr and 8 μ R/hr, respectively. Using Wilcoxon's Sum of Ranks Test, the difference between outdoor gamma levels in Rolling Hills and Bradley was statistically significant ($p < 0.002$). The higher gamma radiation levels in Rolling Hills could result from the presence of phosphate mining wastes near the surface of the reclaimed land.

The ratio of the mean outdoor gamma radiation levels in Rolling Hills to Bradley was 1.6; the ratio of the mean indoor radon levels in Rolling Hills to Bradley was 4.6. Therefore, radon levels in Rolling Hills were elevated proportionally more than the gamma radiation levels. This suggests the higher radon levels in Rolling Hills could be due, in part, to greater soil gas permeability in the reclaimed areas.

The State of Florida has recommended that gamma exposure rates for public exposure to naturally occurring radioactivity in the environment should not exceed 20 μ R/hr in new homes, schools, and commercial buildings (100-91, Florida Administrative Code). The highest indoor level of gamma radiation detected in this survey was 19 μ R/hr, which was detected in one house in Rolling Hills. Therefore, none of the indoor air gamma radiation levels detected in this investigation pose a public health hazard.

212 *Pollock and Nall*

REFERENCES

- SATCHILL, M. (1995). "Sinkholes and stacks: Neighbors claim Florida's phosphate mines are a hazard." U.S. News & World Report, June 12, pp. 53-56.
- PERSHAGEN, G., AKERBLOM, G., AXELSON, O., CLAVENSJO, B., DAMBER, L., DESAI, G., ENFLO, A., LAGARDE, F., MELLANDER, H., SVARTENGREN, M., and SWEDJEMARK, G.A. (1994). "Residential radon exposure and lung cancer in Sweden." N. Engl. J. Med. 330(3):159-164.
- PHOSPHATE LAND RECLAMATION COMMISSION (1978). Phosphate Land Reclamation Commission Report on Phosphate Mining and Reclamation. Report No. FL/SCR-78-011.
- ROESSLER, C.E., ROESSLER, G.S., and BLOCH, W.E. (1983). "Indoor radon progeny in the Florida phosphate mining region-a review." Health Physics 45(2):389-396.
- U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA) (1992). A Citizen's Guide to Radon (2nd ed.) May 1992. Washington, DC. Report No. ANR-464.

Manuscript Received: November 26, 1996

Manuscript Accepted: August 29, 1997